

Spherical Coordinate Systems for Streamlining Suited Mobility Analysis

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Introduction:

When describing human motion, biomechanists generally report joint angles in terms of Euler angle rotation sequences. However, there are known limitations in using this method to describe complex motions such as the shoulder joint during a baseball pitch.

Euler angle notation uses a series of three rotations about an axis where each rotation is dependent upon the preceding rotation. As such, the Euler angles need to be regarded as a set to get accurate angle information. Unfortunately, it is often difficult to visualize and understand these complex motion representations.

It has been shown that using a spherical coordinate system allows Anthropometry and Biomechanics Facility (ABF) personnel to increase their ability to transmit important human mobility data to engineers, in a format that is readily understandable and directly translatable to their design efforts.

Objectives: The goal of this project was to use innovative analysis and visualization techniques to aid in the examination and comprehension of complex motions.

Methods: This project consisted of a series of small sub-projects, meant to validate and verify a new method before it was implemented in the ABF's data analysis practices. A mechanical test rig was built and tracked in 3D using an optical motion capture system. Its position and orientation were reported in both Euler and spherical reference systems.

In the second phase of the project, the ABF estimated the error inherent in a spherical coordinate system, and evaluated how this error would vary within the reference frame. This stage also involved expanding a kinematic model of the shoulder to include the rest of the joints of the body.

The third stage of the project involved creating visualization methods to assist in interpreting motion in a spherical frame. These visualization methods will be incorporated in a tool to evaluate a database of suited mobility data, which is currently in development.

Results: Initial results demonstrated that a spherical coordinate system is helpful in describing and visualizing the motion of a space suit. The system is particularly useful in describing the motion of the shoulder, where multiple degrees of freedom can lead to very complex motion paths.